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Surface Relief Grating Formed by Light Irradiation on Photochromic Polymer and Photochromic Polymer - Conducting Polymer Composite and Their Novel Optical Properties

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Introduction

Recently, formation of surface relief grating on photochromic polymer film containing photochromic azobenzene substituents in the side chain upon irradiation of two interfering beams of a low power laser has attracted much attention from both fundamental scientific interest and practical view points for the applications in optoelectronics. On the other hand, conducting polymers whose main chains have highly extended conjugated π-electron system have also attracted much interest because of their novel characteristics and various applications utilizing them.

In this study, surface relief gratings are formed on the surfaces of photochromic polymer and also photochromic polymer – conducting polymer composite upon irradiation of two polarized interfering light beams. Their novel optical properties are also discussed.

Experimental

The molecular structures of photochromic acrylate azo-polymer containing azobenzene as photochromic moiety in the side chain and conducting polymer, poly (2-methoxy-5-dodecyloxy-*p*-phenylenevinylene) (MDDOPPV) are shown in Fig. 1.

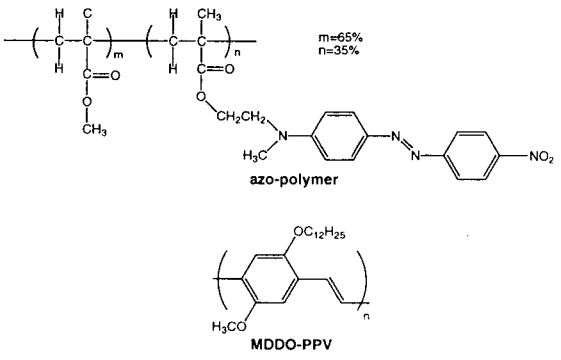

Fig. 1: Molecular structures of photochromic polymer and conducting polymer used in this study

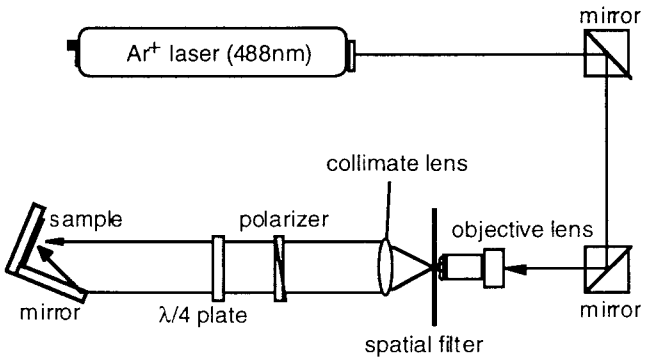

Fig. 2 : Experimental geometry for recording of the surface relief grating

The grating was recorded using a simple interferometric geometry as shown in Fig. 2. By changing the angle between two writing beams, the periodicity of the grating could be controlled. Recording light source is Ar^+ laser at a wavelength of 488nm. The polarization of two recording lights were circularly polarized using a λ/4 plate. The surface profile of the recorded relief grating was investigated by an atomic force microscope (AFM), JSTM-4200A (JOEL). Photoluminescence spectrum was measured using a CCD multichannel spectrometer (Hamamatsu, PMA-11).

Results and Discussion

Figure 3 shows the AFM profile of the surface relief grating recorded on the pure azo-polymer film using two interfering beams of a recording light (488nm). The surface of the film is periodically lifted according to the distribution of the light intensity due to the interference. The periodicity of the formed surface relief grating was controlled from 300 to 2000nm by the angle between two writing laser beams.

Also on the azo-polymer film doped with the conducting polymer MDDOPPV, surface relief grating could be formed as the same manner as that on the pure azo-polymer. MDDOPPV has an intense photoluminescence (PL), so we measured the angular dependence of the PL intensity emitted from the composite film having surface relief grating. Upon the excitation (488nm in wavelength) of the surface relief grating on the composite film, an intense PL was observed as shown in Fig. 4. It should be noted in this figure that sharp emission peaks were observed at specific observation angle ϕ in the PL spectrum. It should also be mentioned that the peak position also depends strongly on the periodicity of the grating. This directional characteristic of PL emission can be explained not by a simple diffraction theory, but in terms of the oscillation of the PL intensity from the periodicity of surface relief gratings.

By irradiating subsequently another interfering beam with change of writing angle upon the surface on which the surface grating was formed, a periodically aligned (hexagonal) dotted pattern, that is, two dimensional (2D) grating structure, was formed as shown in Fig. 5. The formation of this structure was confirmed by the observation of diffraction pattern from the 2D-grating structure with He-Ne laser (Fig. 6). This 2D-grating of the dotted structure is also interesting as a method for the formation of photonic crystal.

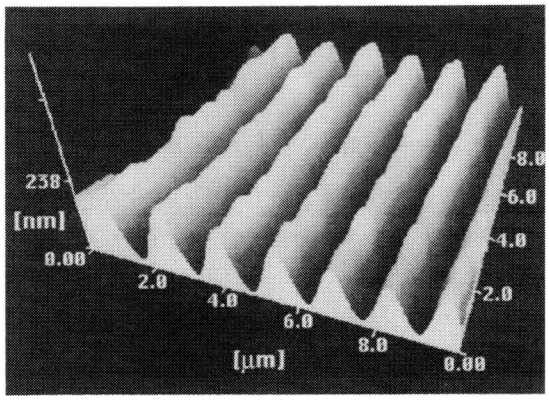

Fig. 3 : Atomic force microscope profile of the formed surface relief gratings on the photochromic azo-polymer film.

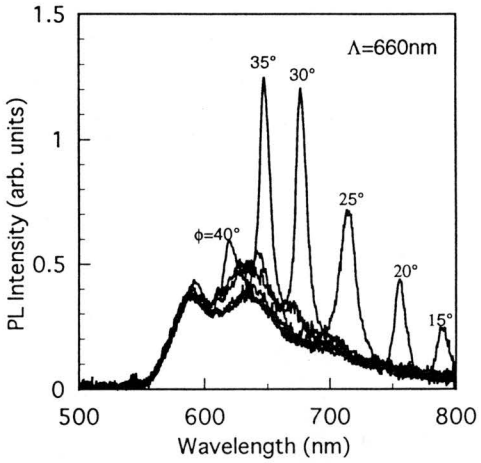

Fig. 4 : Photoluminescence spectrum emitted from the composite film having surface relief grating with the periodicity of 660nm as a function of the monitoring angle .

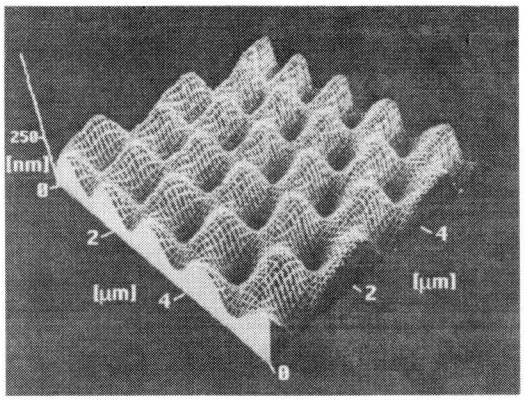

Fig. 5 : Atomic force microscope profile of the formed two-dimensional surface gratings on the photo-chromic polymer.

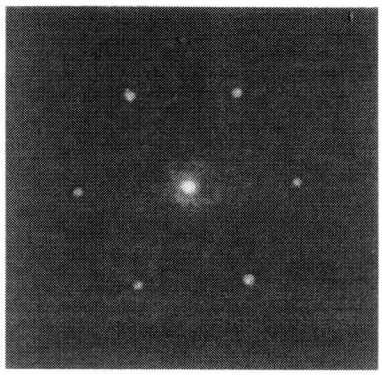

Fig. 6 : Diffraction pattern of He-Ne laser from two-dimensional (hexagonal) surface gratings.

References

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